

Task 2.5: Vertical Variations in PM and PM Precursor Concentrations in the San Joaquin Valley

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Background

- In the winter, strong temperature inversions can result in significantly different pollutant concentrations aloft than at the surface.
- Key questions:
 - How do concentrations vary vertically?
 - Do day/night differences in mixing height and temperature explain vertical concentration variations?
 - Can aloft versus surface transport be isolated?
 - How do trends at an elevated site compare to those taken in the Valley aloft and at the surface?

Approach

- Examine diurnal concentrations of and ratios between species aloft and at ground
- Compare aloft and ground concentrations between night and day
- Examine dependence on wind directions by day/night and aloft/ground
- Compare concentrations during episodes at an elevated site (Sierra Nevada Foothills) with aloft and ground data from Valley sites

Site Locations



Site Details

ANGIOLA (ANG) – 60 m MSL

- Remote arid location
- Meteorological and air quality measurements taken at surface (7 m AGL) and 90 m AGL (on 100-m tower)
- At 90m and surface, nephelometer, aethalometer, nitrate, OPC, NO, NO_y, O₃

WALNUT GROVE (WAG) – 3 m MSL

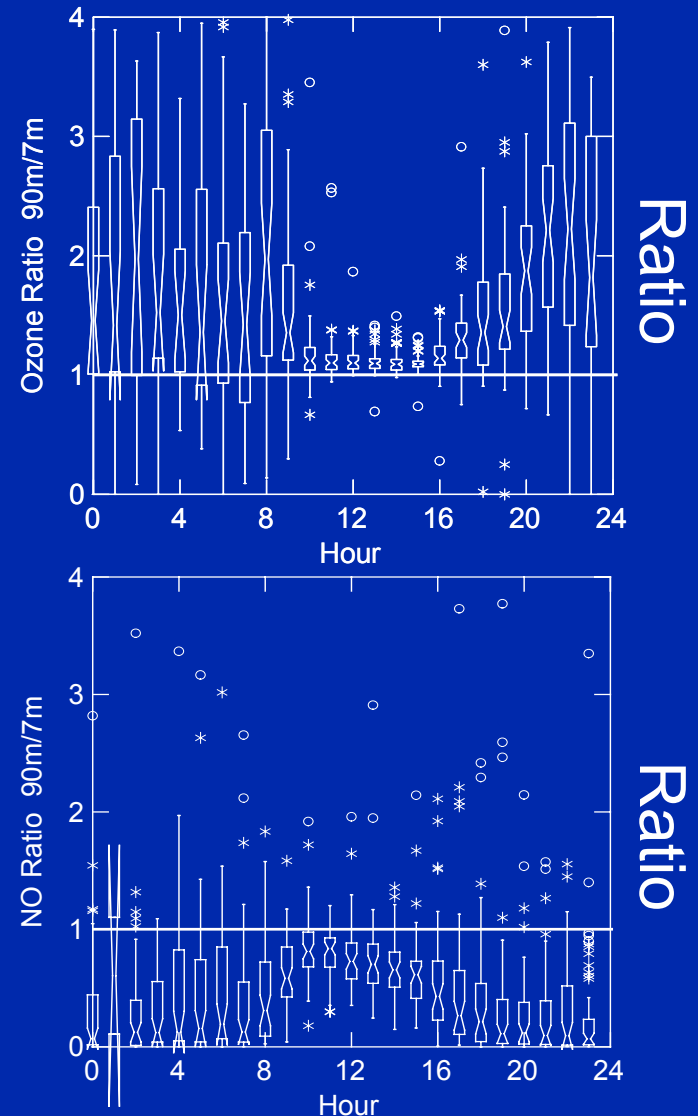
- Rural site in corridor between Bay Area and San Joaquin Valley
- Meteorological and air quality measurements taken at 10 m AGL and 245 m AGL
- Nephelometer, aethalometer, nitrate

SIERRA NEVADA FOOTHILLS (SNF) – 589 m MSL

- Remote rural area
- Meteorological and air quality measurements taken at 6 m AGL

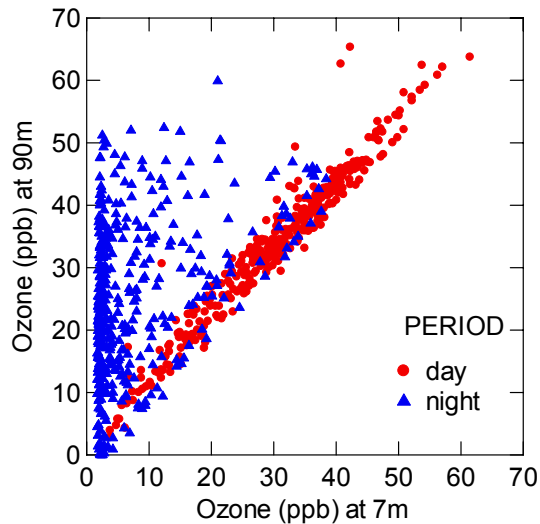
O₃ and NO: Diurnal Trends at ANG

- Ozone and NO show complementary diurnal trends.
- Ratio much different from 1 suggests tower and surface are separated (occurred at night)
- Ratio ~1 suggests tower and surface were in the same mixed environment (occurred at midday)
- At night, ozone is depleted at the surface and higher aloft, while NO is depleted aloft and is much higher at the ground.

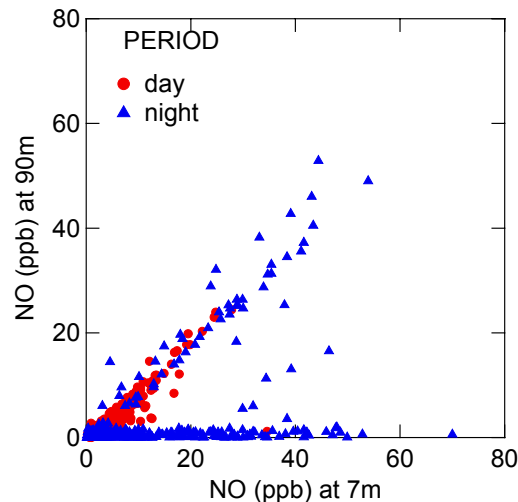


Day vs. Night: Angiola NO and O₃

Ozone



NO



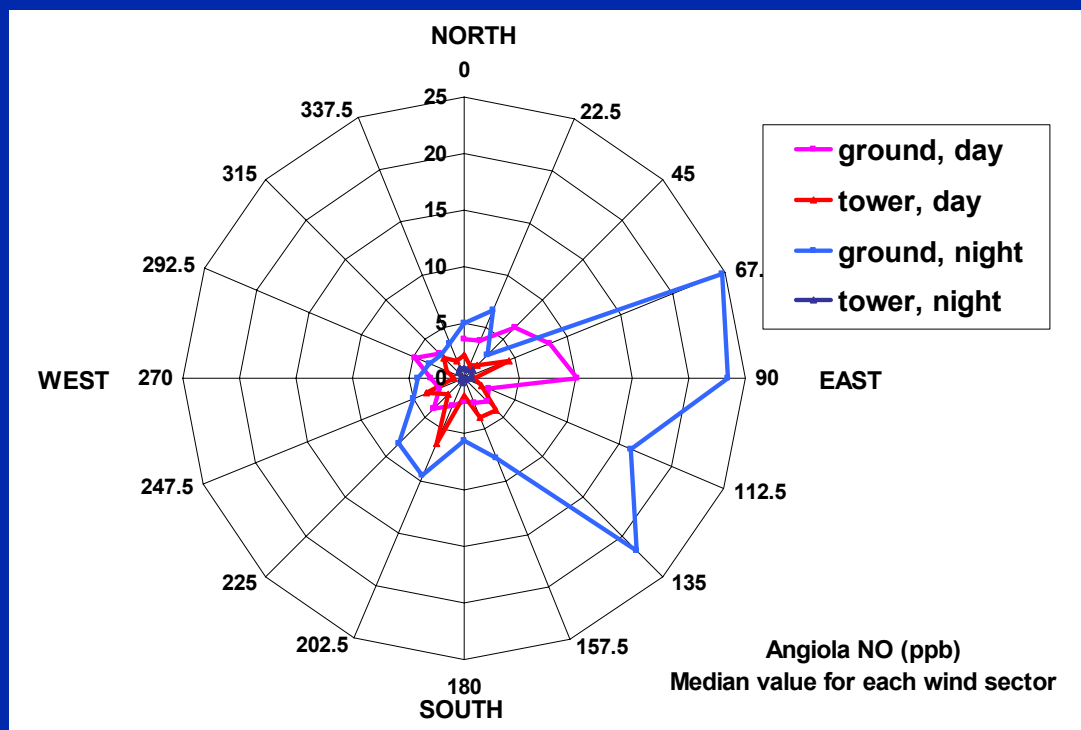
- Titration of O₃ by NO occurs during the day, when atmosphere is well-mixed
- Stratified layer at night leads to depletion of O₃ at surface while aloft the NO is titrated away and no new emissions of NO occur
- Very high NO at surface and minimal O₃ at night suggests local source of NO

Day=1100-1600 PST (inclusive)

Night=2200-0500 PST (inclusive)

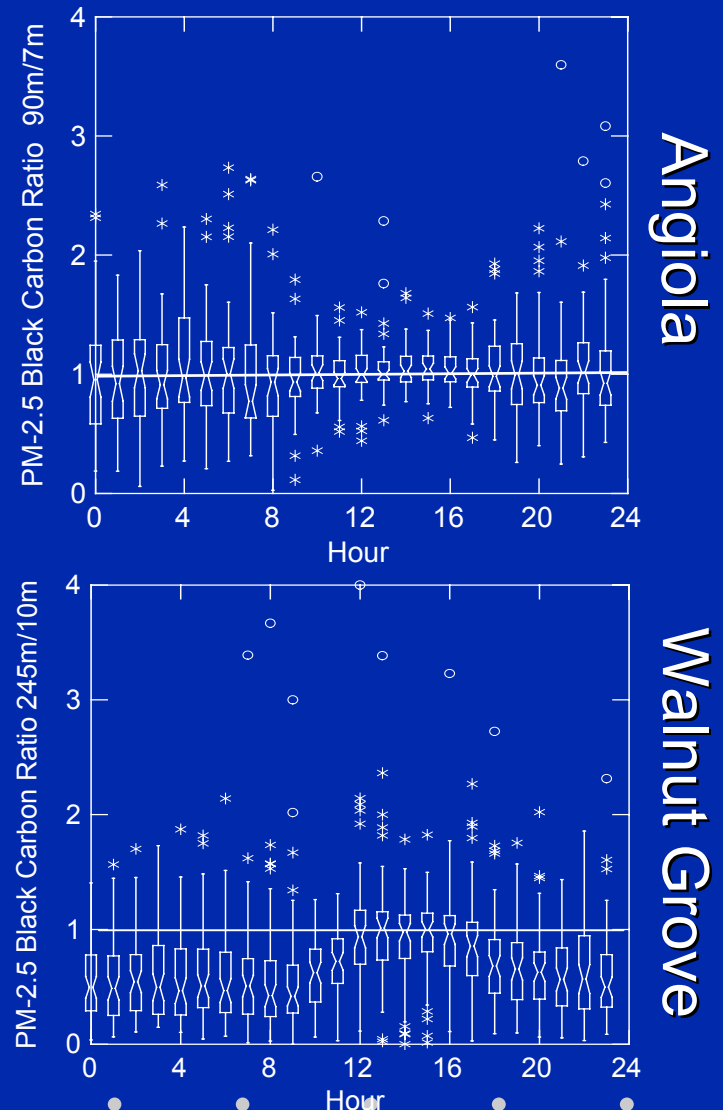
Angiola NO

- Highest NO concentrations occur at the surface during nighttime from east and southeast.
- U.S. Route 99, a north-south route with heavy truck traffic, lies approximately 8 miles to the east of Angiola.
- Local transport during nighttime



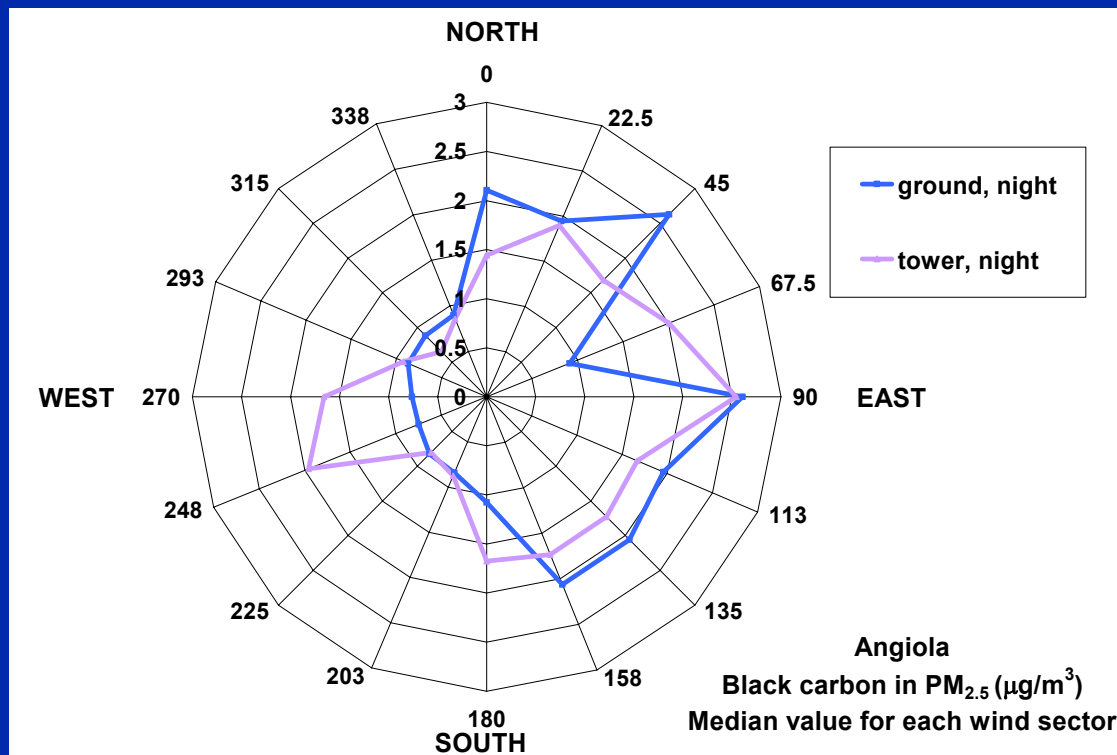
Black Carbon: Diurnal Trends

- No distinct diurnal BC trend at Angiola, though more variability at night:
 - Difference compared to Walnut Grove may be typical of differences between 90 m and 245 m in the Valley.
 - Sources and sinks of BC may be balanced aloft and at surface (regional?)
- Distinct diurnal BC trend at Walnut Grove:
 - Mixing during day distributes throughout the vertical.
 - Higher concentrations at surface at night from transport along surface.



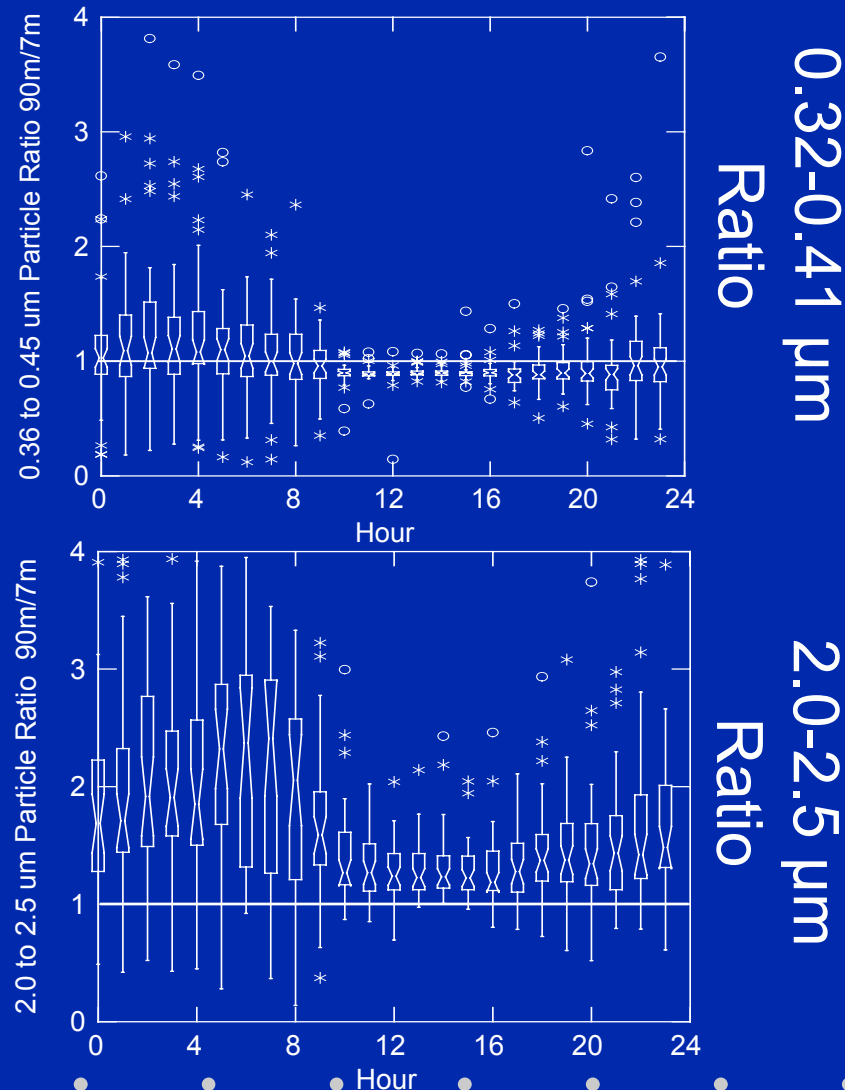
Angiola Black Carbon

- Highest BC concentrations during the night come from east, northeast, and southeast.
- Segregating by wind direction shows similar trends as diurnal ratios
- Similar concentrations aloft and at ground with wind from east differs from NO data, suggesting different sources



Angiola PM

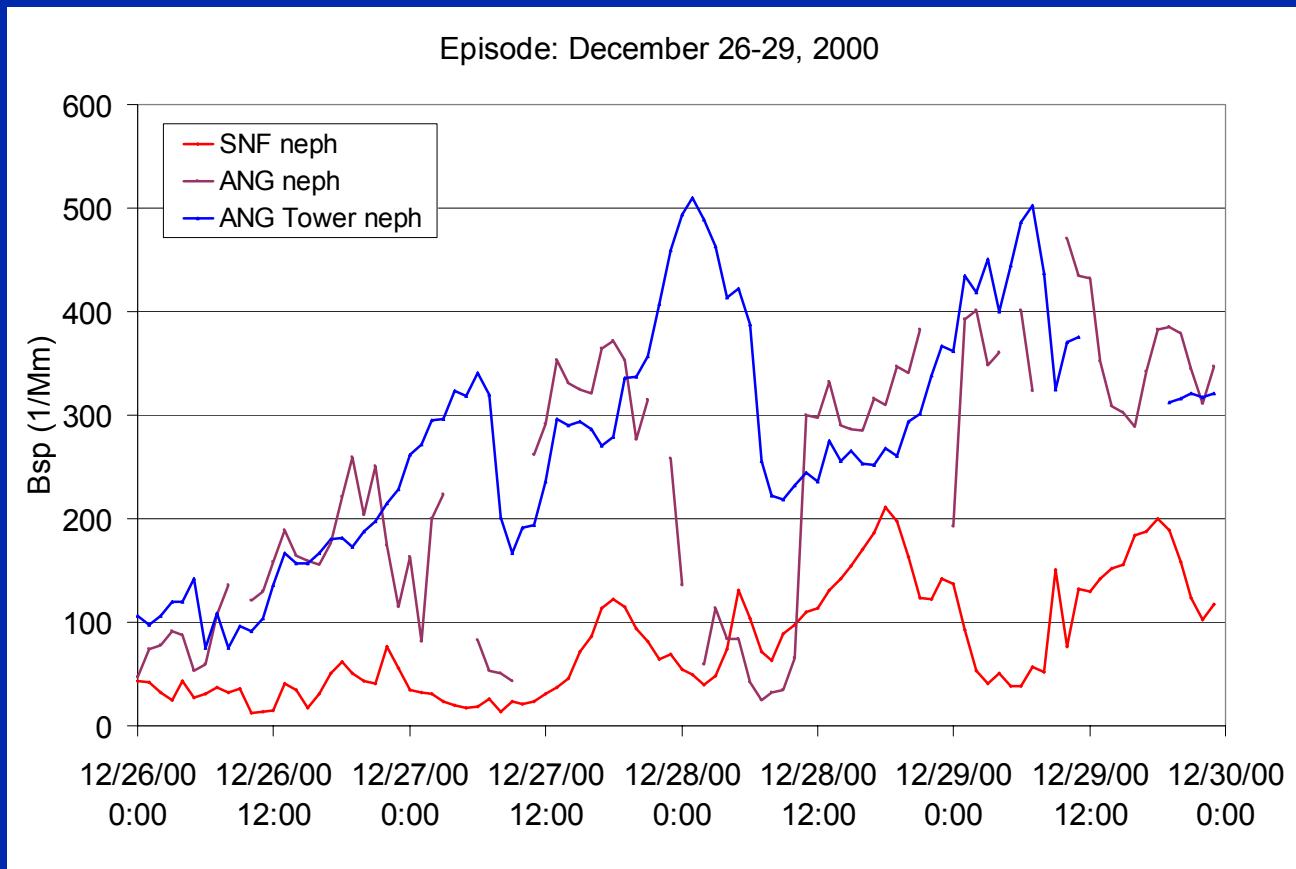
- Particle counts for bins $<0.52 \mu\text{m}$ show little difference between aloft and surface (see example)
- This diurnal trend is similar to BC
- Particle counts are higher aloft for bins in the $0.52\text{--}3.5 \mu\text{m}$ range (see example) especially at night
- Ratio >1 suggests tower environment different than surface (occurred during nighttime)



Sierra Nevada Foothills

- Are concentrations at this elevated rural site affected more by transport along Valley floor or aloft?
 - Compared SNF diurnal profiles to tower and ground at ANG and WAG
 - Also examined two IOP periods
- Strong diurnal patterns look more like a surface site, even though SNF is at a higher elevation.
- Strong diurnal patterns at SNF most similar to Fresno, though much lower in concentration.
- During episodes, SNF does not match the pattern seen at ANG or WAG (next slide example)

Dec 26-29, 2000 Episode: Nephelometers



Summary

- Both Angiola and Walnut Grove data show stratification at night
- At Angiola, parameters show different diurnal vertical trends:
 - During the night, ozone is higher aloft while NO is higher at the ground, and both are well-mixed through the vertical in the afternoon
 - BC concentrations are uniformly distributed through the vertical throughout the day and night
 - Particle counts for bins between 0.52 and 3.5 μm are higher aloft than at the surface except during the afternoon
- At Walnut Grove, BC, nitrate, and scattering are higher at the surface throughout the day until the afternoon
- Sierra Nevada Foothills site more like a surface site than either of the towers

Conclusions

- Towers were useful for characterizing vertical pollutant distribution in the Valley
- Diurnal trends in the vertical distribution of pollutants differed by pollutant
- At night at Angiola, conditions were conducive to nitrate formation aloft
- Diurnal trends of BC aloft and at the surface show regional influence while diurnal trends of NO demonstrate local influence
- Counts for larger particles (bins 0.52-3.5 μm) were higher aloft, contrary to conceptual model
- Sierra Nevada Foothills site not useful for characterizing vertical pollutant distribution in the Valley

Site Measurements (1 of 3)

Angiola

Air Quality Measurement	Angiola Surface	Angiola 45 m	Angiola 90 m
Radiance Research Nephelometer Particle Scattering (b_{sp})	X	X	X
Climet Optical Particle Counter (0.3 to 10 μm)	X	X	X
Magee Scientific Aethalometer PM _{2.5} Black Carbon (BC)	X		X
Rupprecht & Patashnick PM _{2.5} Nitrate (NO ₃)	X		X
Thermo Environmental Nitric Oxide and Reactive Oxides of Nitrogen (NO and NO _y)	X		X
Advanced Pollution Instruments Ozone (O ₃)	X		X

Site Measurements (2 of 3)

Walnut Grove

Air Quality Measurement	Walnut Grove 14 m	Walnut Grove 245 m
Radiance Research Nephelometer Particle Scattering (b_{sp})	X	X
Magee Scientific Aethalometer $PM_{2.5}$ Black Carbon (BC)	X	X
Rupprecht & Patashnick $PM_{2.5}$ Nitrate (NO_3^-)	X	X

Site Measurements (3 of 3)

Sierra Nevada Foothills

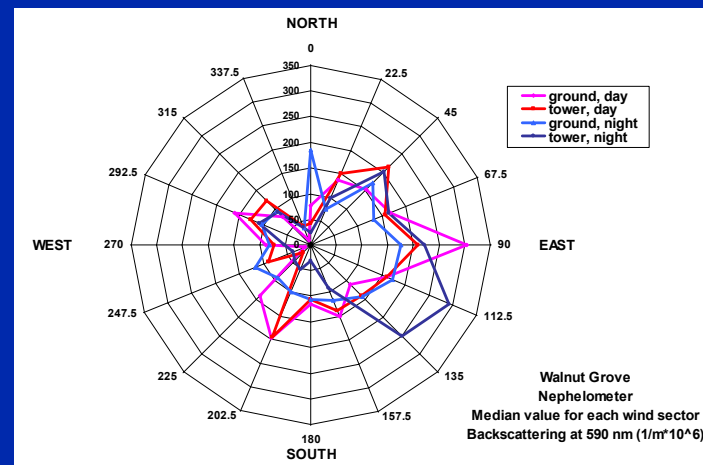
Air Quality Measurement	Sierra Nevada Foothills
Radiance Research Nephelometer Particle Scattering (b_{sp})	X
Magee Scientific Aethalometer $PM_{2.5}$ Black Carbon (BC)	X
Met One $PM_{2.5}$ Beta Attenuation Monitor ($PM_{2.5}$ mass)	X
Rupprecht & Patashnick $PM_{2.5}$ Nitrate (NO_3)	X
Thermo Environmental Nitric Oxide and Reactive Oxides of Nitrogen (NO and NO_y)	X
Advanced Pollution Instruments Ozone (O_3)	X
Thermo Environmental Nitric Acid and Reactive Oxides of Nitrogen (HNO_3 and NO_y)	X

Walnut Grove Nephelometer

Most particle backscattering at Walnut Grove is from air masses from east.

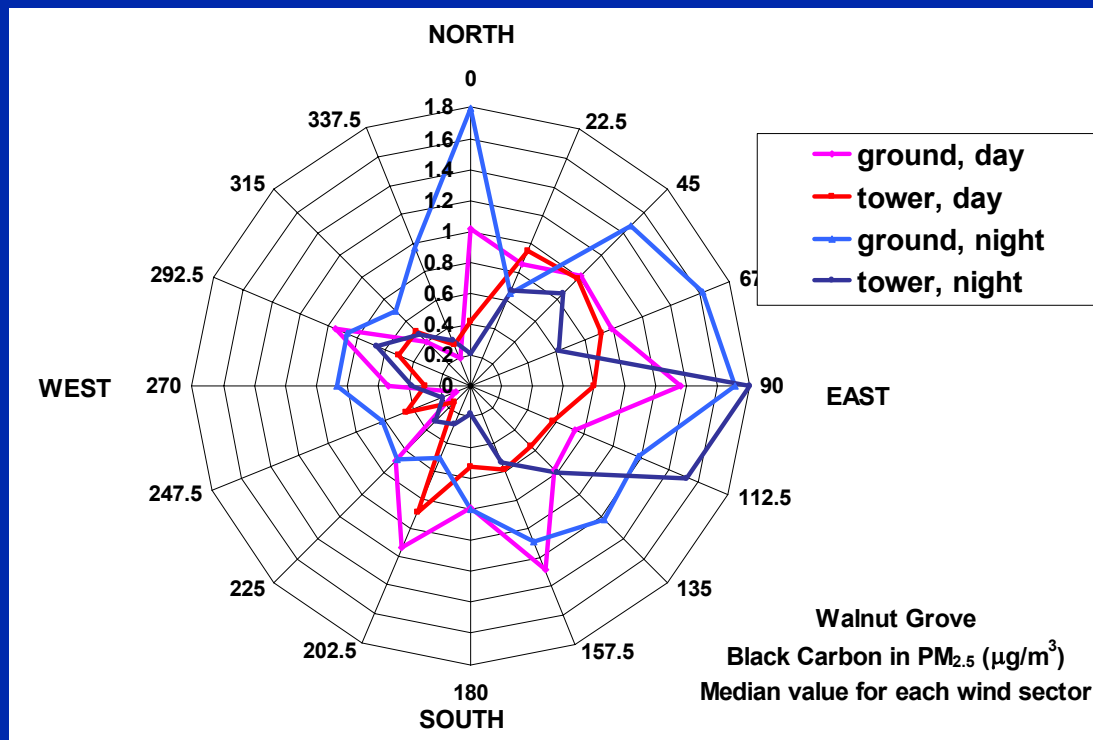
Sources of particle backscattering include Interstate 5, U.S. Route 99, transport from greater San Joaquin Valley.

Very high aloft b_{sp} from southeast at night could indicate long-range transport from San Joaquin Valley in aloft layer.



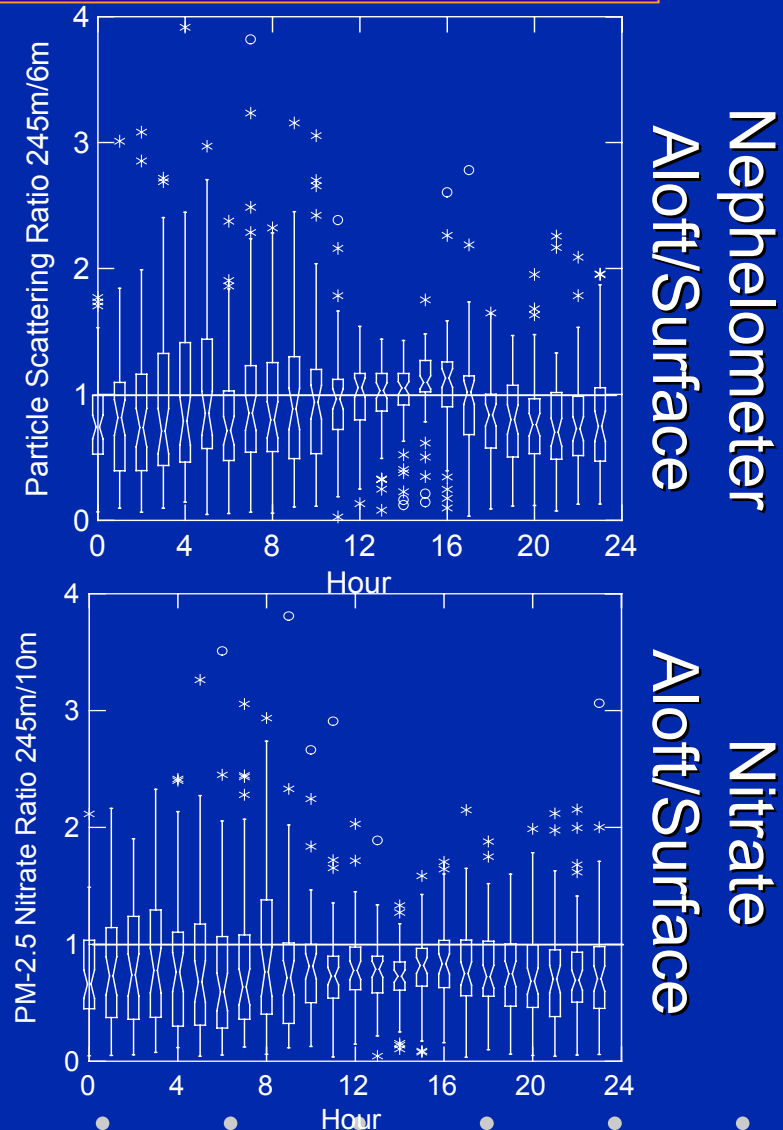
Walnut Grove Black Carbon

- BC higher from east during day/night at tower/ground
 - Interstate 5 is approximately 4 miles east of Walnut Grove.
 - BC at night at ground level from the north could be from Sacramento / Interstate 80 (25 mi N).
 - Highest BC concentrations during nighttime aloft are predominantly from east – transport from Valley?



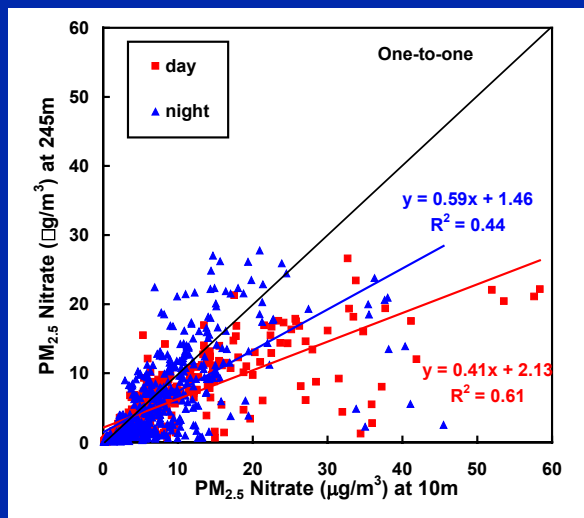
Walnut Grove: Diurnal Trends

- At night, Walnut Grove scattering is higher at the surface than aloft.
 - Similar to the BC diurnal trend
 - PM emissions could be trapped at the surface layer
- Walnut Grove nitrate concentrations are consistently higher at the surface than aloft.
 - Ratio approaches unity at midday; offset may be instrument bias
 - Other than not reaching unity in afternoon, results are consistent with nephelometer and BC data

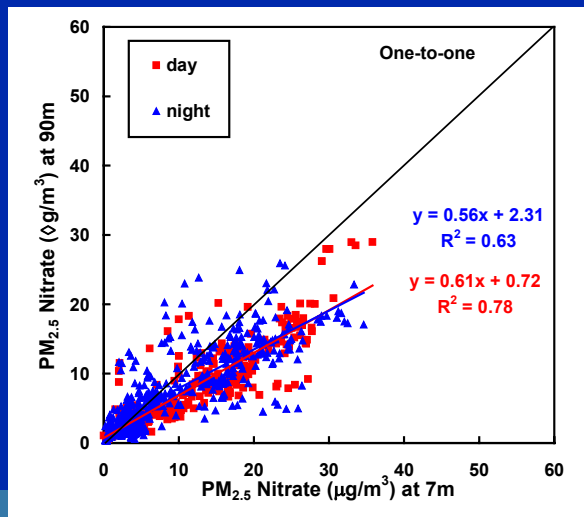


Day vs. Night: Nitrate

Walnut Grove



Angiola



- At both sites, there is scatter during day and night.
- More scatter at Walnut Grove demonstrates various transport regimes
- Lack of day/night differential seems odd in context with precursor differences

Day=1100-1600 PST (inclusive)

Night=2200-0500 PST (inclusive)

Dec 26-29 2000 Episode: Surface Nephelometers

